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# **Uncertainties and Interdisciplinary Transfers Through the End-to-End System (UNITES): Capturing Uncertainty in the Common Tactical Environmental Picture**

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## **LONG-TERM GOALS**

UNITES is a unique interdisciplinary team with expertise spanning the environment (physical oceanography and bottom geology), ocean acoustics (propagation, ambient noise, reverberation and signal processing), and tactical sonar systems. The overall goals of the research are to enhance the understanding of the uncertainty in the ocean environment (including the sea bottom), characterize its impact on sonar system performance, and provide the Navy with guidance for understanding sonar system performance in the littoral. Professor Miller will be involved in the explicit calculation of the transfer of uncertainty from the environment through the sonar system outputs, and will investigate the applicability of specialized mathematical techniques for stochastic systems.

## **OBJECTIVES**

Specific objectives of the team effort are to: 1) Develop generic methods for efficiently and simply characterizing, parameterizing, and prioritizing sonar system variabilities and uncertainties arising from regional scales and processes. 2) Construct, calibrate and evaluate uncertainty and variability models, for the sonar systems and its components, to address forward and backward transfer of uncertainties. 3) Transfer uncertainties from the acoustic environment to the sonar and its signal processing, in order to effectively characterize and understand sonar performance and predictions.

## **APPROACH**

Our technical approach is based on utilizing environmental probability density functions (PDF) to provide a description of sonar performance. The PDFs will be determined for appropriate spatial and temporal scales as dictated by the systems under consideration. In particular, these PDFs will be determined for the following: meso- and sub-mesoscale fronts and eddies, tides, internal tides, waves and solitons, interference variability (ambient noise and reverberation) and spatially variable bottoms. Professor Miller will work with teammates on design, performance and evaluation of Monte-Carlo experiments which will be used to calculate explicit PDF's and evaluation of the resulting PDF's themselves, and will work on the development of new techniques based on the stochastic calculus (see, e.g., Kloeden and Platen, 1995) if they are found to be necessary.

## **WORK COMPLETED**

We have been working with the Harvard group, and contributed to the team presentation in San Diego in June, 2002.

## **RESULTS**

Rigorously correct calculation of the evolution of the uncertainty in the end-to-end system resulting from uncertainty in the environment requires the application of the tool of the formal stochastic calculus. In this case, the Stratonovich formulation is the appropriate one. Even so, conventional techniques may provide suitable approximations.

## **IMPACT/APPLICATIONS**

The primary application is to assist the sonar "prediction community" by providing a probabilistic representation of sonar system performance. The present approach provides a systematic method to incorporate uncertainties due to the environment and to transfer the effects of these uncertainties, in the end-to-end problem through the sonar systems under consideration. The operator can thus use this information to operate the system more effectively and make more informed decisions on search, risk, expenditure of assets (weapons) and assumptions of covertness.

## **TRANSITIONS**

## **RELATED PROJECTS**

"Theory and Practice of Data assimilation in Ocean Modeling" is an ongoing project sponsored by ONR with Professor Miller as PI. Recent work has emphasized calculation of PDF's of an increasingly complex sequence of strongly nonlinear models.

## **REFERENCES**

Kloeden, P. E. and E. Platen, 1995: "*Numerical Solution of Stochastic Differential Equations.*" Springer-Verlag, 632pp.

Miller, R. N. and L. L. Ehret, 2001: Ensemble generation for models of multi-modal systems. *Mon. Wea. Rev.*, **130**, 2313-2333.

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## **PUBLICATIONS**